Sensor and Simulation Notes

Note 144

General Principles for the Design of

ATLAS I and II

Part II:

ATLAS: Electromagnetic Design Considerations for Vertical Version

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ATLAS:

Electromagnetic Design Considerations for Vertical Version

1. Earth shaping under trestle

- two options just as in the case of the horizontal version but the implications have some differences

A. taller trestle over basically flat earth

- simplifies earth shaping and has simpler electromagnetic considerations - allows various aircraft entry

B. shorter trestle over earth mound

- more complex earth shaping and more complex electromagnetic considerations

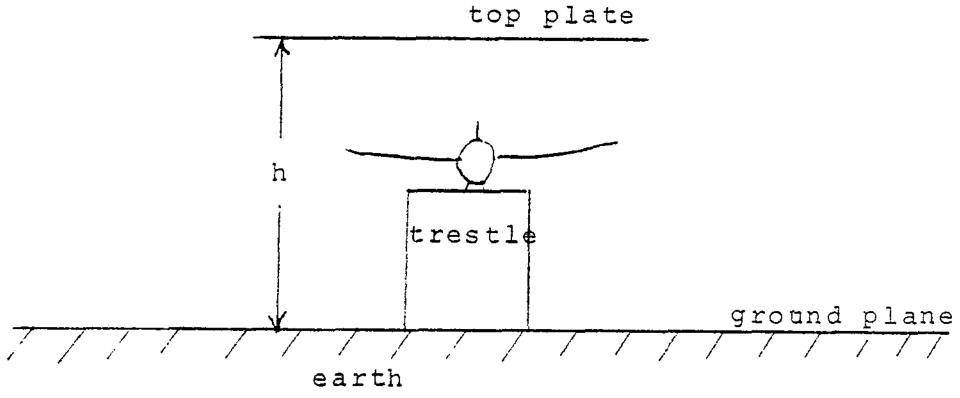
- alternately this becomes a ridged TEM transmission line simulator. Consider first the A option - then modify to include the B option

A1 Plate spacing

- made large enough to avoid distortion of current and charge on aircraft associated with both top and bottom plates more than some desired amount

- this can be a severer problem than the case of one plate

- this also chooses the trestle height



A2 Top plate width

- chosen on basis of field uniformity in working volume

- bottom plate on ground assumed infinitely wide

A3 Bottom plate width

- designed on basis of being infinite

- should extend on each side of top plate a distance of order h - avoids propagation losses due to earth

- earth level can then begin to rise but not so sharply as to send reflections of the incident pulse back into the working volume.

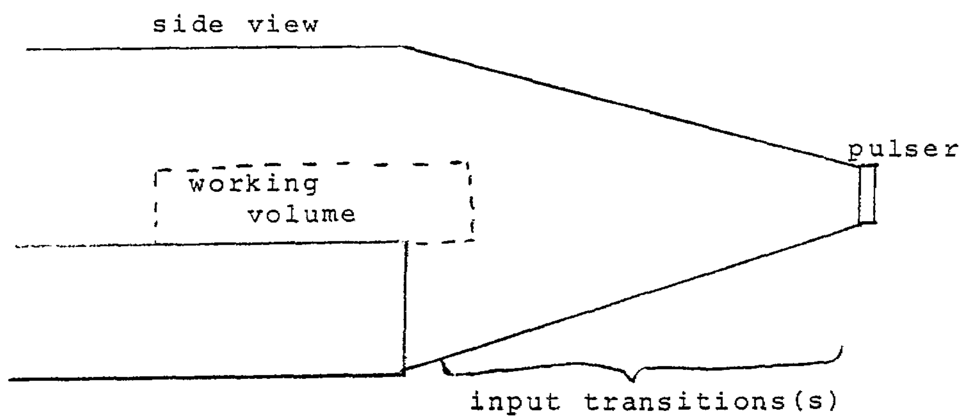
A4 Impedance of simulator

- this comes from spacing and top plate width

- earth beyond bottom ground plane has some effect but this can be made small for wide enough ground plane and not too radically rising earth beyond this.

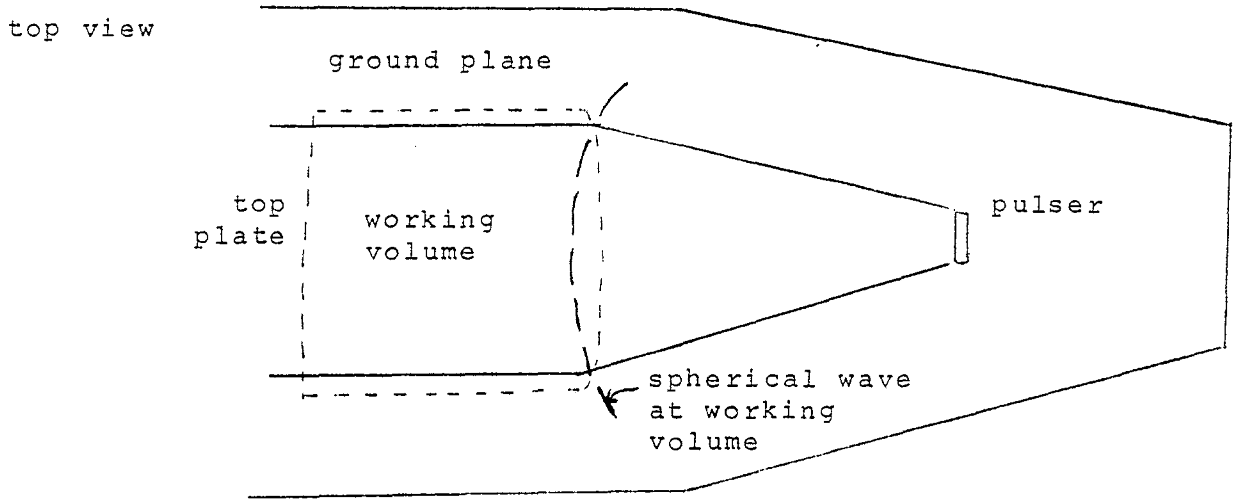
A5 Working volume relative to input transitions

- no large metal in center at end of input transitions as in horizontal case - therefore working volume can be closer (like in ARES)

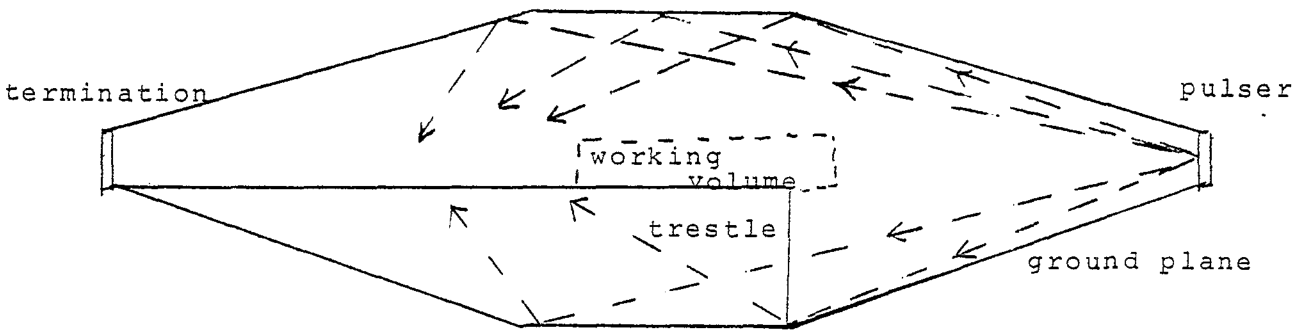


A6 Length of input transition: case of only one

- first question is planarity over the working volume - since working volume is much wider than it is high the variation in arrival time over the width is dominant concern



- second question is diffraction at bends or more generally the geometrical optics considerations

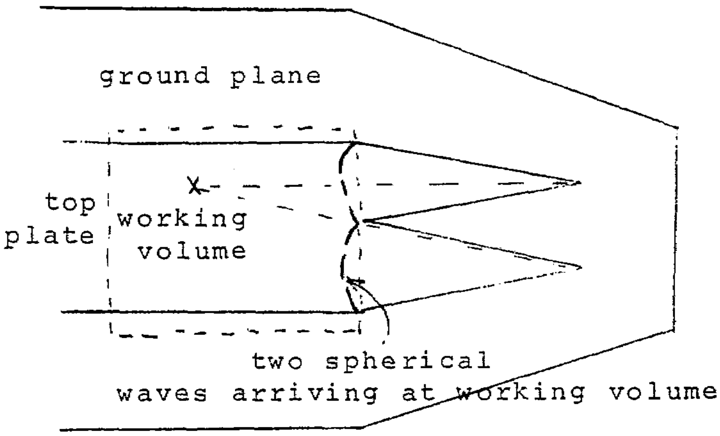


- make sure all the reflected rays clear the working volume and allow some room to spare for the "diffracted" waves from the bends

A7 Length and shape of input transitions: case of two transitions

from planarity viewpoint two parallel transitions can be used to shorten transition length - note this is because working volume is so wide

top view

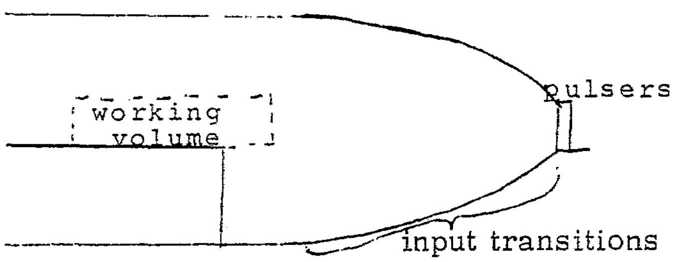


Note two waves arrive at each observer in the working volume, one from each source. The difference in these times is an additional planarity issue. The spacing between the two transition apexes needs to be optimally chosen as well as the transition length.

- the diffraction at bends is still important and this may require that the transitions not be so short that the incident wave scatter off the top plate and ground plane into or close to the working volume

- the transition top plates and/or ground plane should be approximately curved to account for their mutual interaction so as to maintain a constant impedance at each cross section

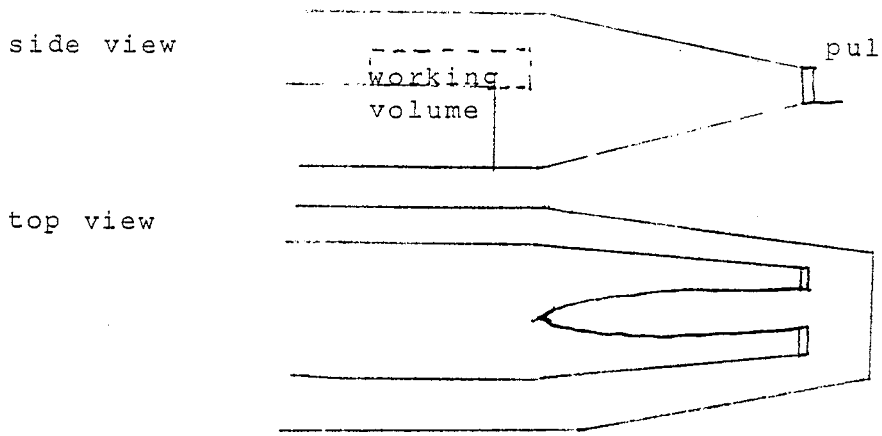
side view



- for "curving" the top plates several flat sections can be used, requiring intermediate dielectric poles or other support along the input transitions

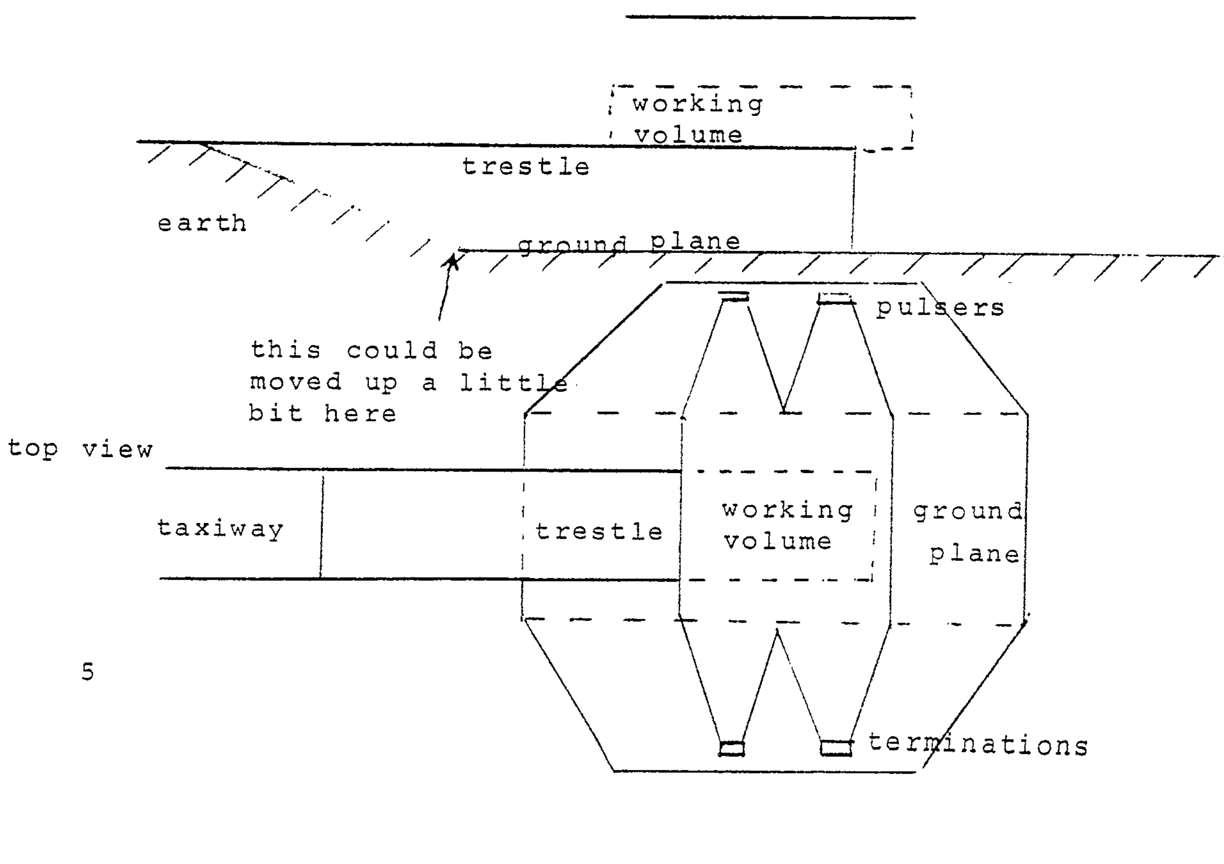
- note that the plate curving introduces more complex geometrical optics considerations as well as reducing the initial amplitude in the working volume (except right in the center) because of the larger angle of divergence of the plates near the sources compared to the ultimate plate spacing

- alternative is to make the plates flat but curve their edges as



- note that the ground plane extends under both transitions and to the outside of each to a distance of the order of the local height of the transitions or more.

A8 Side entry of aircraft applying to any termination design

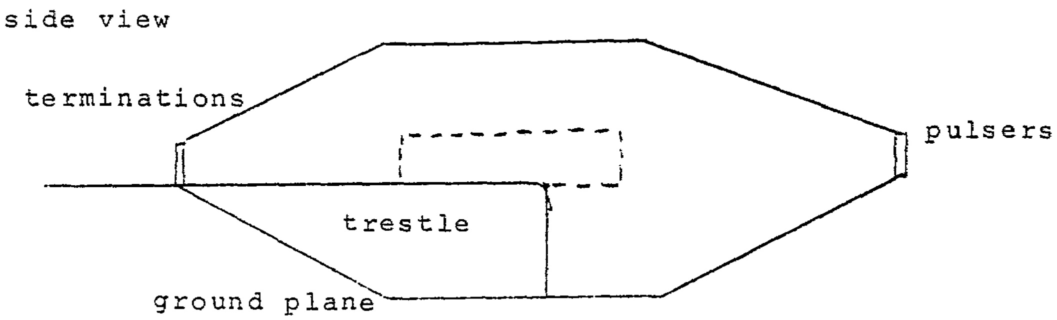


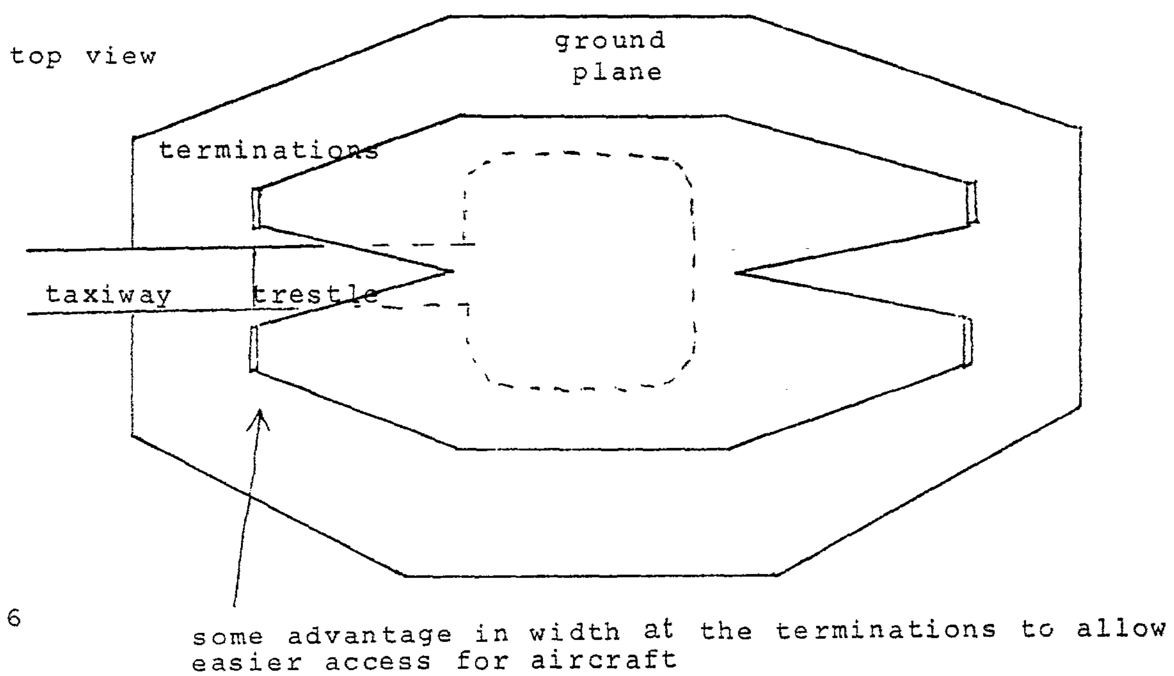
- this has the advantage of not having to move anything to get the aircraft in and out

- single or double termination transition sections both apply for this side entry

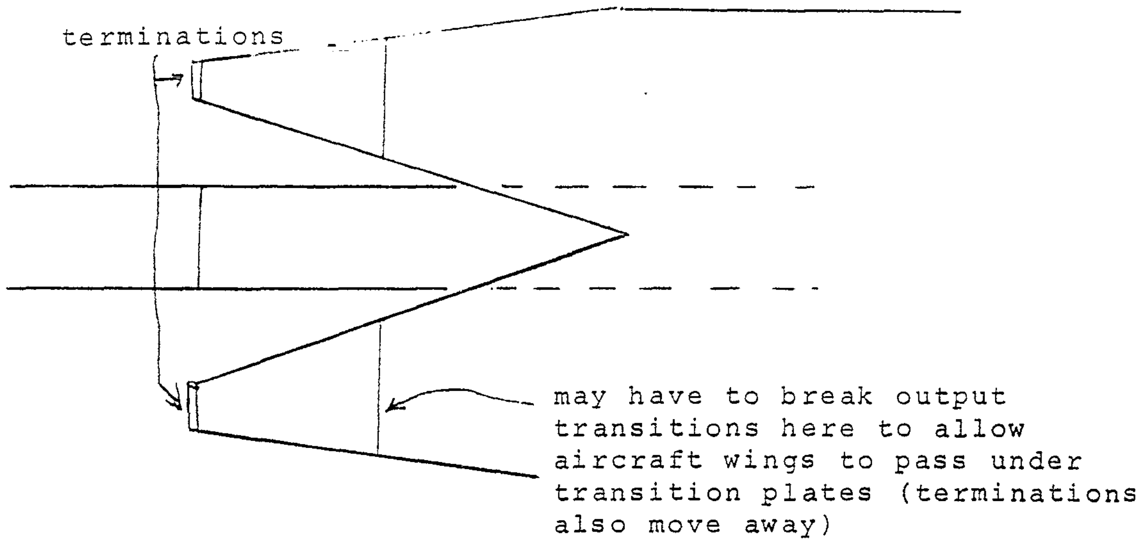
- note side entry applies for option A where we have no earth mound under the trestle

A9 Rear entry of aircraft





top view of termination section



- This requires intermediate supports (such as dielectric poles) together with tiedown mechanisms to hold any tension designed into the top plates while still allowing clearance for wings.

- Note for rear entry case a double termination transition has the advantage of allowing easy passage of the vertical stabilizer on an aircraft entry - a single termination transition would have to be broken much closer to the working volume to permit entry of the same large aircraft

A10 Terminations

- same design considerations as in horizontal simulator

A11 Transmission line and transitions for launch and termination: structure of conductors

- same as for horizontal case

- metal beams, etc. in particular can be used for horizontal spans in top plate, substituting in part for catenaries if desired

A12 Ground planes and sheilding for volumes

- same as for horizontal case

- note here ground plane is on earth surface and ground plane quality as a function of where in the simulator a particular portion happens to be is a question very similar to the ARES ground plane

A13 Poles for holding up transition sections and transmission lines

- must be mostly dielectric

- no metal support poles here

A14 Design of pulser arrays if arrays instead of single point sources are used

- same as case for horizontally polarized transmission line

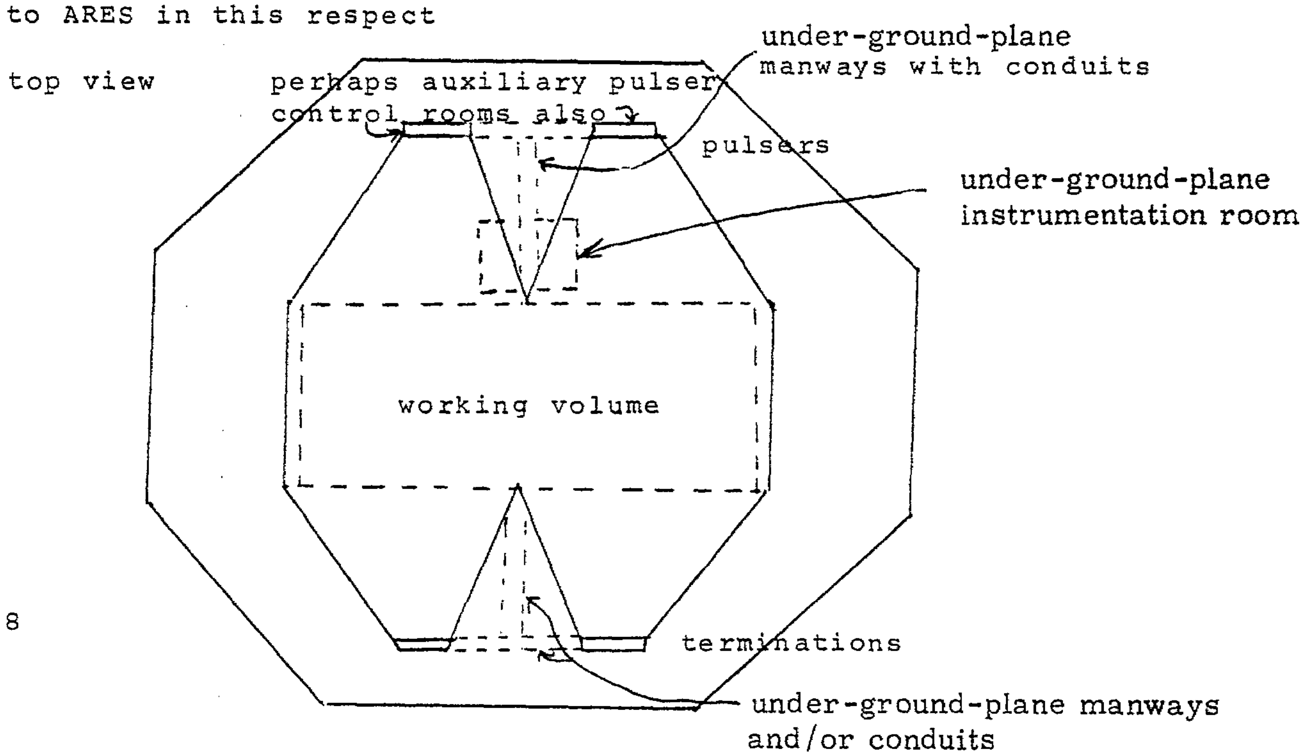
A15 Connection of two portions of top plate together (if applicable)

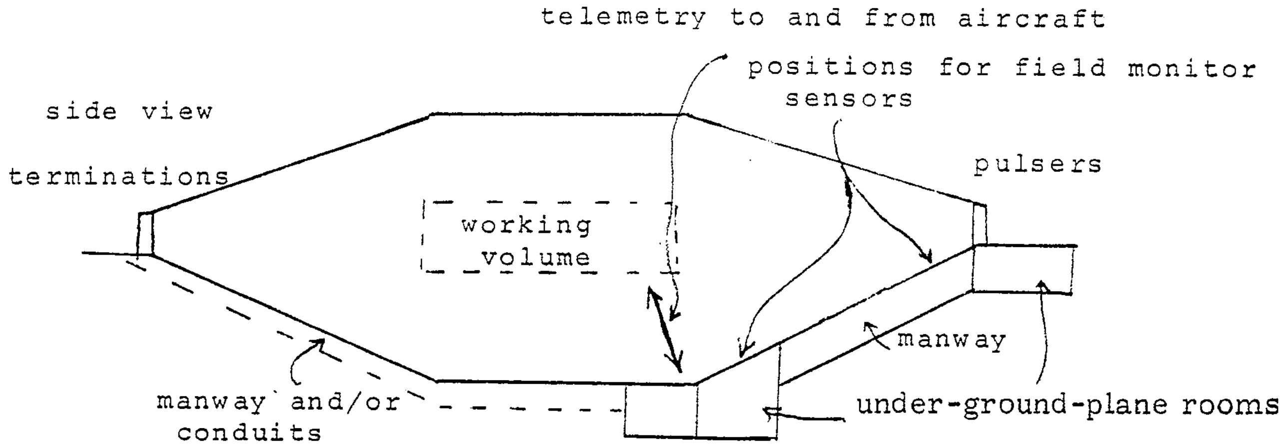
- for case of double input transition

- the transmission line plates are cross wired to avoid any loops of the order of a wavelength at the highest frequencies of interest or less - but if two capacitive pulsers with very low loss connect to separate transition sections then the top plate should be divided so as to avoid a large low impedance loop through the transition sections and ground plane - some resistance should be in the path such as through the terminations, resistors between the plate halves, and/or resistance in the pulsers.

A16 Location of pulser controls and instrumentation recording rooms

- vertically polarized simulator is very similar to ARES in this respect





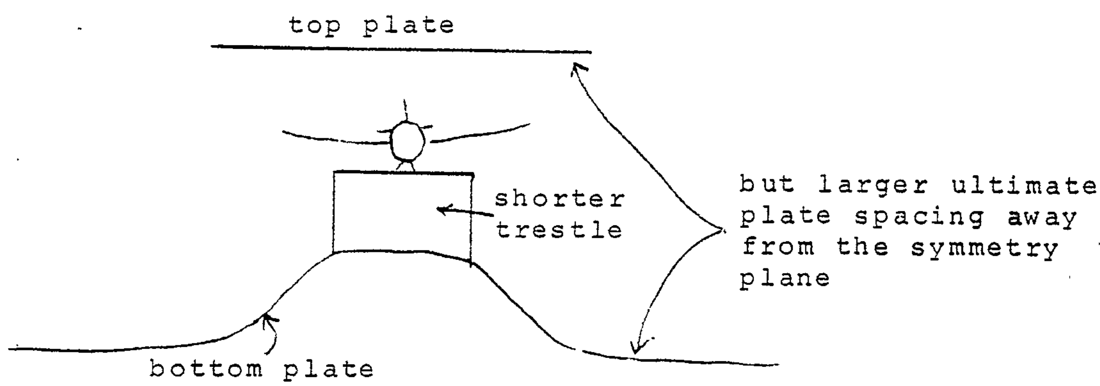
B. Consider now the B option insofar as it introduces modifications into the A considerations

- note only rear entry considered here because of presence of earth mound which should be symmetrical with respect to a plane parallel to the direction of propagation in the simulator

- of course one might consider entry from the source end but the raised earth portion had best see the wave "after" the aircraft

- see B4 to go into what may be a better variant as a ridged TEM type of waveguide - entry could be from either end

B1 Plate spacing with presence of mound



- the bottom plate can be considered to have one or more equivalent flat plate positions, depending on which effect is being considered. Various effects include maintaining the same impedance, the same fields in the working volume, the same coupling of the aircraft resonances, etc. to the top and bottom plates, etc.

- Note that this type of simulator differs from the horizontally polarized case in that the curved bottom plate is now highly conducting since it is one of the fundamental conductors for the transmission line

B2 Mound consistency

- since the mound is hidden behind a highly conducting surface none of it need be earth - it could be partially steel for example

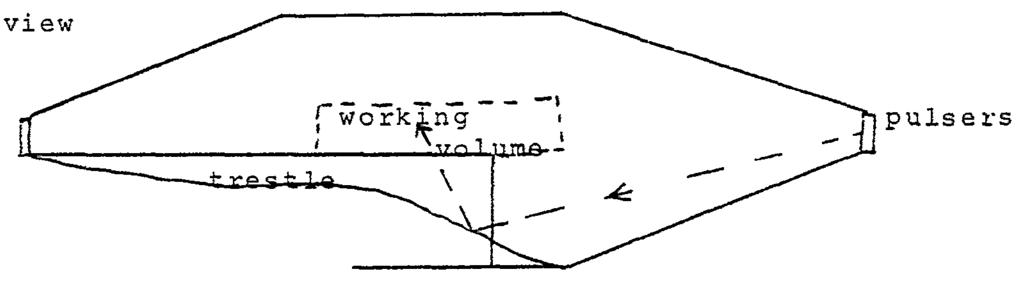
B3 Geometrical optics considerations

- as in horizontal case we wish to avoid the reflection of the incident wave at high frequencies off the mound and up into the working volume

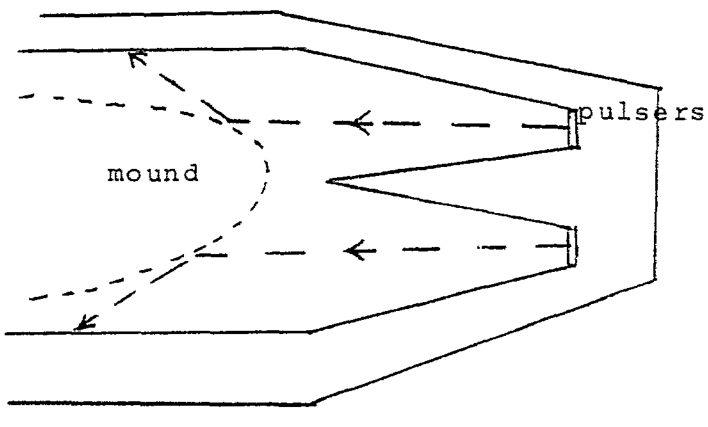
- but now we have a more severe problem in that the reflection coefficient at the surface is unity, significantly larger than dry earth

- we still want to make these rays that bounce up into the working volume bounce only from convex parts of the mound surface with sufficiently small radius of curvature

side view



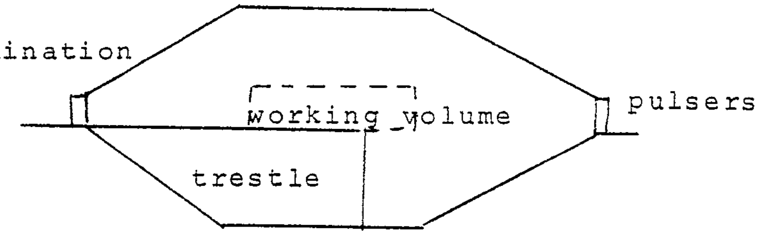
top view



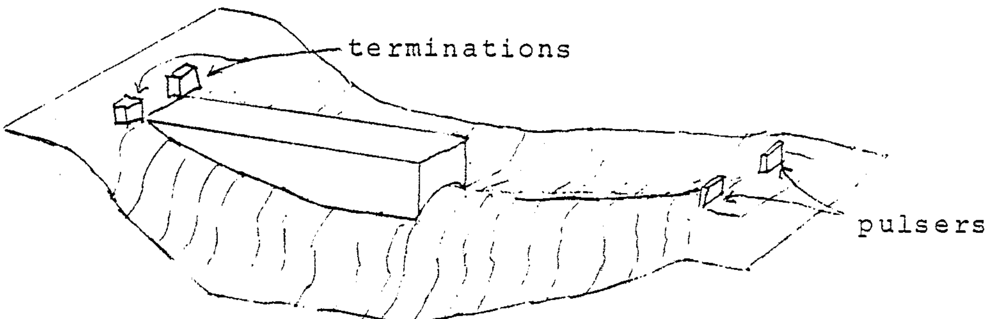
B4 Alternate approach to completely avoid these optical reflection problems from the ground plane, viz.

the uniform mound or ridged TEM waveguide

side view



angular view of ground plane

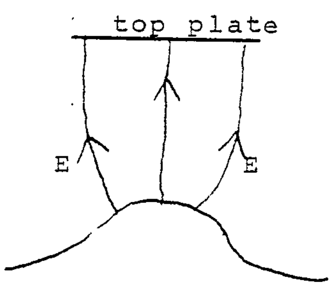


- basically the mound goes from end to end in the entire simulator keeping the same ratio of dimensions

- the corresponding inhomogeneities in the TEM fields are included in launch and termination as well

- be careful in that for a double wave launcher and/or terminator the mound gets wider but less high as the dual pulsers and/or terminators are approached

- the pulser arrays would be slightly tilted to better match the tilt of the electric field on each side of the mound



pulsers at connection to transitions

- note that aircraft entry could be from either end in that the mound is the same at both ends

- however one might still prefer the aircraft entry to be from the end away from the most simulator activity - why move pulsers, for example, or have taxiways over underground instrumentation rooms or build the trestle over an underground room? - such under-ground-plane facilities would tend to be toward the pulser end of the simulator

- note now that the under-ground-plane instrumentation rooms and manways are not really underground anymore, but are hidden inside the ridge near the pulser end of the facility.

B5 Dual termination transition - rear entry

top view